

Clinical evaluation and related factor analysis of intrarenal pressure using a Chinese-made disposable pressure-measuring flexible ureteroscope

Yubao Liu, Haifeng Song, Zheng Xu, Weiguo Hu, Bo Xiao, Gang Zhang, Boxing Su, Bixiao Wang, Jianxing Li*

Department of Urology, Beijing Tsinghua Changgung Hospital, School of Clinical Medicine, Tsinghua University, Beijing, 102218, China

LIU Y, SONG H, XU Z, HU W, XIAO B, ZHANG G, SU B, WANG B, LI J. Clinical evaluation and related factor analysis of intrarenal pressure using a Chinese-made disposable pressure-measuring flexible ureteroscope. *Can J Urol* 2026;33(3):685–692.

Objective: The pressure fluctuations during retrograde intrarenal surgery (RIRS) can cause related complications, so precise monitoring and control of intrarenal pressure (IRP) play an important role. This study aimed to assess the clinical value of a Chinese-made disposable pressure-measuring flexible ureteroscope in monitoring IRP during RIRS for upper urinary tract stones <2 cm, and analyze factors affecting IRP.

Methods: In this prospective single-arm study, 35 patients (38 renal units) underwent RIRS. Mean age was 42.3 ± 6.1 years, body mass index (BMI) 24.2 ± 2.6 kg/m², and maximum stone diameter 1.6 ± 0.4 cm. Stones were located in the ureter (21.1%), kidney and ureter (15.8%), or kidney only (63.2%). IRP threshold was 30 mmHg; irrigation used gravity or low-pressure pump. Ureteral access sheath (UAS) size (Fr11–13 or Fr12–14) was selected based on ureteroscopy. Outcomes included safe IRP (<30 mmHg), high/maximum IRP, cumulative time above threshold, influencing factors, infection markers, fever incidence, operative time, stone-free rate, and Visual Analogue Scale (VAS) score.

Results: All procedures succeeded. Mean safe IRP was 10.9 ± 3.4 mmHg, high IRP 63.6 ± 13.5 mmHg, and maximum IRP 181.2 ± 50.5 mmHg. Mean cumulative time above threshold was 485.2 ± 61.3 s. Low-position UAS placement led to significantly higher high IRP, maximum IRP, and longer high-pressure time compared to conventional placement (all $p < 0.05$). UAS size did not significantly affect IRP. Postoperative infection markers showed no difference between mean IRP subgroups (0–30 mmHg vs. 30–60 mmHg). Overweight patients had higher mean IRP than normal BMI patients (26.1 ± 4.2 vs. 15.9 ± 5.7 mmHg, $p < 0.05$). Postoperative fever occurred in 3 cases (8.6%), all with high IRP and prolonged high-pressure exposure. Operative time averaged 45.2 ± 8.3 min, stone-free rate was 92.1%, and mean VAS score was 2.52 ± 0.21 . No major complications occurred.

Conclusions: The disposable pressure-measuring flexible ureteroscope enables real-time IRP monitoring during RIRS, allowing surgical strategy adjustments to improve safety. Low UAS position and high BMI are risk factors for elevated IRP.

Key Words: disposable pressure-measuring flexible ureteroscope, retrograde intrarenal surgery (RIRS), intrarenal pressure (IRP), upper urinary stone

Received date 15 July 2025

Accepted for publication 12 December 2025

Published online 26 June 2026

*Corresponding Author: Jianxing Li. Email: ljx1@sina.com

Introduction

Retrograde intrarenal surgery (RIRS) has long been the first-line surgical treatment for upper urinary tract stones smaller than 2 cm. With advancements in surgical technique and instrument innovation, RIRS is increasingly capable of treating more complex and larger stones.¹ Since the introduction of disposable digital flexible ureteroscopes in 2016, the performance and efficacy of RIRS have improved significantly, marking a new era.^{2,3}

Clinical studies on the Zebra[®] disposable digital ureteroscope have shown comparable efficacy and stone-free rates to reusable fiber-optic or digital ureteroscopes, with significant advantages in image clarity and maneuverability.⁴ Postoperative infectious complications of RIRS are closely related to intrarenal pressure (IRP), and intraoperative pressure monitoring has become a clinical focus. The Zebra[®] pressure-sensing disposable digital flexible ureteroscope, the first of its kind in China, allows real-time and continuous IRP monitoring during lithotripsy. To better understand IRP dynamics, influencing factors, and associations with postoperative infections, we conducted a prospective clinical study using the pressure-sensing ureteroscope for RIRS in patients with upper urinary tract stones <2 cm.

Materials and Methods

General information

This prospective, single-center, single-arm clinical study included 38 renal units (38 cases) of upper urinary tract stones <2 cm. All patients underwent preoperative plain film of kidney-ureter-bladder (KUB) and non-contrast computed tomography (CT) or CT urography to evaluate stone size, distribution, and collecting system anatomy. If the preoperative urine routine examination shows significant infection or positive urine culture, antibiotics or empirical cephalosporins should be used for anti-inflammatory treatment based on drug sensitivity test results. The general course of treatment is 3–5 days. Re-examination of the urine routine indicates significant improvement in infection indicators or a negative urine culture, and surgery can be performed. Four patients with severe inflammatory responses underwent stenting prior to RIRS, and three had stents placed at outside hospitals. Detailed patient demographics and stone-related parameters are shown in [Table 1](#).

This study was approved by the Ethics Committee of Beijing Tsinghua Changung Hospital

(No. 23349-0-02). Informed consent was obtained from all individual participants included in the study.

Instruments and equipment

The Zebra[®] disposable pressure-sensing ureteroscope system was developed and produced by Happiness Workshop Medical Instruments Co., Ltd. (Bengbu, China), which consists of the ureteroscope, image processor, and pressure processor ([Figure 1](#)). The probe tip has a Fr7.5 diameter, with a maximum shaft diameter of Fr8.6 and a 3.6 Fr working channel. The bidirectional deflection reaches >275° with or without a 200- μ m holmium laser fiber. The tip houses a CMOS sensor (160,000 pixels) and a fiber-optic pressure sensor with 0.01 mmHg accuracy. The pressure module displays real-time pressure, duration, and cumulative time above the 30 mmHg threshold, and a composite “Zebra Index” (excess pressure \times time; [Figure 2](#)). The image processor is compatible with external monitors. In addition, in order to better describe and reflect the clinical significance of pressure measurement, some IRP-related parameters are defined: (1) Safe IRP: refers to the range of pressure between 0 and 30 mmHg; (2) High IRP: refers to the range where the pressure exceeds 30 mmHg or more.

Surgical technique

All procedures were performed under general anesthesia in the lithotomy position. A Fr8-9.8 ureteroscope was used to place a guidewire, followed by inspection of the entire ureter and renal pelvis. Upper ureteral stones were pushed into the kidney before lithotripsy. A ureteral access sheath (UAS; Fr11/13 or Fr12/14, 35–50 cm) was inserted according to ureteral conditions. Balloon dilatation was performed for focal strictures. If access sheath placement failed, a ureteral stent was placed, and surgery was rescheduled. Irrigation was delivered via gravity (1.2–1.5 m height) or a low-flow pump (\leq 100 mL/min). A 200- μ m holmium laser was used for dusting (15–20 Hz, 0.5–1 J) or fragmentation (10–15 Hz, 1.2–1.5 J). Some fragments were retrieved for analysis. IRP monitoring started upon entry into the renal pelvis and ended at lithotripsy completion. A Fr6 stent was left postoperatively for 2–4 weeks. KUB was reviewed on day 1–2, and a follow-up KUB or CT (When preoperative CT values or KUB estimates indicate uric acid or cysteine stones) was done at one month. Stone-free status was defined as \leq 2 mm residual fragments. Complications were graded using the Clavien-Dindo classification.

TABLE 1. Baseline characteristics, perioperative data, and outcomes

Category	Variable	Value
	Number of patients, n	35 (38)
	Male, n (%)	19 (54.3)
	Female, n (%)	16 (45.7)
Demographics	Age, years (mean ± SD)	50.1 ± 12.7
	Body mass index (BMI), kg/m² (mean ± SD)	25.9 ± 4.7
	Ethnicity, n (%)	
	Han	33 (94.3)
	Other	2 (5.7)
Underlying disease	Hypertension, n (%)	6 (17.1)
	Diabetes, n (%)	9 (25.7)
	Cardiac disease, n (%)	4 (11.4)
	Chronic Kidney Disease (CKD), n (%)	2 (5.7)
	Other, n (%)	2 (5.7)
Previous surgery	Stent placement, n (%)	7 (18.4)
	RIRS/URL, n (%)	6 (15.8)
	Percutaneous nephrolithotomy (PCNL), n (%)	2 (5.7)
	Stone size, cm (mean ± SD)	1.6 ± 0.4
	Stone location, n (%)	
Stone characteristics	Renal	24 (63.2)
	Ureteral	8 (21.1)
	Both	6 (15.8)
	Stone composition, n (%)	
	Calcium oxalate	17 (44.7)
	Struvite/Apatite	11 (28.9)
	Mixed	9 (23.7)
	Uric acid	1 (2.6)
	Hydronephrosis, n (%)	
	None	7 (18.4)
Mild	26 (68.4)	
Moderate or above	5 (13.3)	
Perioperative data	Operation time, min (mean ± SD)	45.2 ± 8.3
	Hospital stay, days (mean ± SD)	3.8 ± 0.6
	Urinary tract infection (UTI), n (%)	31 (88.6)
	Urine culture positive, n (%)	9 (25.7)
	Stone-free rate (SFR), n (%)	35 (92.1)
	Complications, n (%)	
	Fever	3 (8.6)
Outcomes	Bleeding (transfusion required)	0
	Organ injury	0
	Sepsis	0

Note: Abbreviations: SD, standard deviation; CKD, chronic kidney disease; RIRS, retrograde intrarenal surgery; URL, ureterolithotripsy.

Statistical analysis

SPSS 22.0 (IBM Corp., Armonk, NY, USA) was used for analysis. Normally distributed data are expressed as mean ± standard deviation (SD); non-normal data

as median (range). *t*-tests, ANOVA, *F*-tests, and chi-square tests were used as appropriate. *p* < 0.05 was considered statistically significant.

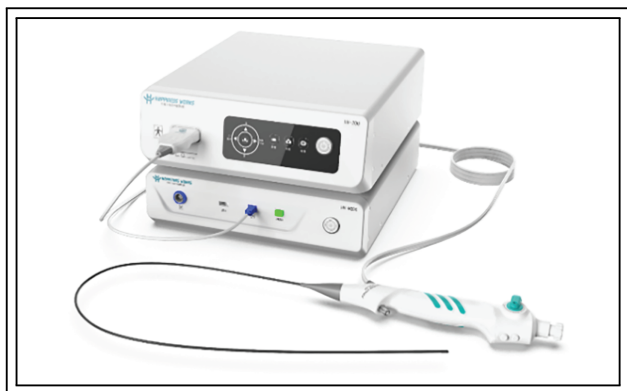


FIGURE 1. Zebra[®] disposable intrarenal pressure (IRP) measuring flexible ureteroscopy System: Pressure-measuring flexible ureteroscopy, image processor, and pressure measurement processor

Results

RIRS was successfully performed in 35 patients (38 renal units). Low UAS placement (mid-ureter or upper ureter) occurred in 9 cases (25.7%), and standard placement (1–2 cm below renal pelvis) in 29 cases (76.3%). The mean safe IRP was 10.9 ± 3.4 mmHg; high IRP, 63.6 ± 13.5 mmHg; peak IRP, 181.2 ± 50.5 mmHg. Mean cumulative time above 30 mmHg was 485.2 ± 61.3 s. Sex, pre-stenting, hydronephrosis, and stone location were not significant IRP influencers ($p > 0.05$). Different UAS sizes (Fr11/13 vs. Fr12/14) showed IRP differences (38.9 ± 15.7 mmHg vs. 25.1 ± 7.3 mmHg, $p = 0.0713$), but not statistically significant. UAS position and body mass index (BMI) significantly influenced IRP ($p < 0.05$). Low-position UAS cases had higher high/peak IRP and longer cumulative pressure durations ($p < 0.05$). Overweight patients had higher IRP than those with normal BMI ($p < 0.05$, Table 2). IRP remained <60 mmHg for 91.5% of total surgery time, and <15 mmHg for 56.3% (Figure 3). No significant difference in white blood cell (WBC), procalcitonin (PCT), or C-reactive protein (CRP) was found between IRP subgroups (0–30 vs. 30–60 mmHg) at 2 and 24 h post-operation ($p > 0.05$, Table 3). Three cases (8.6%) had low-grade postoperative fever, all associated with higher IRP and prolonged high-pressure duration. Their mean IRP were 52.7, 75.2, and 63.3 mmHg, respectively. The mean operative time was 45.2 ± 8.3 min, and one-month SFR was 92.1% of all patients; VAS was 2.52 ± 0.21 . No Clavien-Dindo \geq II complications occurred.

Discussion

RIRS is effective and safe, with fewer complications and rapid recovery. It remains a first-line treatment for urinary stones ≤ 2 cm.⁵ With improved technology and disposable devices, indications have expanded to larger stones.^{6,7} Larger stone burdens require longer operation times and higher irrigation, increasing IRP. Excessive IRP (>35 mmHg) can lead to endotoxin absorption via pyelovenous, pyelolymphatic, or pyelosinus pathways, contributing to postoperative SIRS, sepsis, or even renal rupture.⁸ Studies report IRP during RIRS ranging from 40.8 to 199.35 mmHg.^{9,10} Intraoperative IRP monitoring is essential for preventing complications.

Existing methods for IRP monitoring include placing pressure catheters in the renal pelvis or within UAS channels. Yang et al.¹¹ used a 4 Fr ureteral catheter inserted through the auxiliary channel of a dual-lumen UAS for pressure measurement and recorded an initial IRP of 13.2 ± 5.6 mmHg and a peak IRP of 95.6 ± 2.3 mmHg. Osther et al.¹² placed ureteral catheters into the renal pelvis or UAS, connecting the distal end to invasive pressure transducers or urodynamic instruments for IRP measurement, yielding a baseline IRP of 10 ± 4.0 mmHg, a mean IRP during endoscopy of 35 ± 10 mmHg, a mean IRP during lithotripsy of 54 ± 18 mmHg, and a peak IRP as high as 328 mmHg. Song et al.¹³ applied a pressure-sensing UAS in RIRS, enabling stable pressure data acquisition and ensuring surgical safety. Traxer et al.¹⁴ used a pressure-sensing guidewire during RIRS to measure IRP, finding a baseline IRP of 4.4 mmHg, a mean IRP of 46.3 mmHg under stable perfusion, and peak pressures between 212.7–321.25 mmHg. Although these methods offer valuable insights, they each have limitations. Pressure catheters and guidewires occupy the working channel, impeding irrigation outflow and complicating the surgical field. Pressure-sensing UAS placement can be difficult in patients with ureteral stenosis, often resulting in suboptimal positioning that fails to reflect true IRP.

The disposable electronic pressure-sensing ureteroscopy effectively addresses these issues. The pressure sensor is integrated into the tip of the ureteroscopy, requiring no additional equipment in the working channel. This allows real-time IRP monitoring directly at the site of lithotripsy, offering both convenience and accuracy. LithoVue Elite™ (LVE) by Boston Scientific was the first disposable ureteroscopy with IRP monitoring. Ben et al.¹⁵ used LVE in a retrospective study of 50 patients undergoing RIRS, confirming the device's effectiveness for IRP monitoring. The median IRP

TABLE 2. Between-group analysis of factors influencing intrarenal pressure (IRP)

Characteristics	IRP (mmHg, mean ± SD)	p-value
Sex		0.786
Male	37.6 ± 13.2	
Female	34.1 ± 12.1	
Hydronephrosis		0.766
No	38.2 ± 16.1	
Yes	34.4 ± 19.7	
Stent placement		0.483
No	32.9 ± 17.4	
Yes	46.1 ± 14.8	
Body mass index (BMI) (kg/m²)		0.043
<24	48.5 ± 18.7	
≥24	25.5 ± 11.4	
Ureteral access sheath (UAS) location		0.033
Upper	27.2 ± 17.7	
Lower	50.2 ± 14.9	
UAS size		0.071
Fr11-13	38.9 ± 15.7	
Fr12-14	25.1 ± 7.3	
Stone location		0.617
Lower pole	39.1 ± 22.7	
Non lower pole	32.6 ± 12.8	

Note. Bold p-values indicate the statistical significance, which are less than 0.05.

was 28.5 mmHg, and the peak was 174 mmHg. Risk factors for high IRP included smaller UAS (Fr10/12), Asian ethnicity, and narrower ureters.

The Zebra[®] disposable electronic pressure-measuring ureteroscope is China's first of its kind. Weighing only 185 g, it provides bidirectional

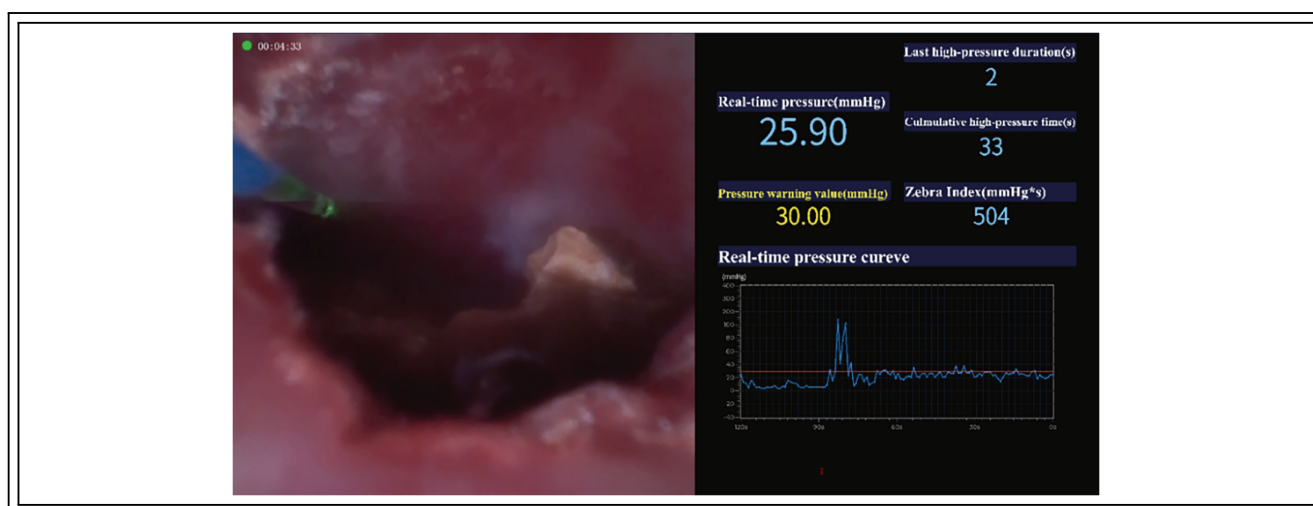


FIGURE 2. Zebra[®] disposable intrarenal pressure (IRP) measuring flexible ureteroscope display: the left screen is a gravel image, and the right screen is a pressure monitoring image

TABLE 3. Between-group analysis of postoperative infection indicators in intrarenal pressure (IRP)

Infection indicators	IRP range (mmHg)	Value (mean \pm SD)	<i>p</i> -value
2 h postoperatively			
WBC ($\times 10^9$ /L)	0–30	8.1 \pm 2.8	0.459
	30–60	9.8 \pm 2.9	
CRP (mg/L)	0–30	7.7 \pm 19.1	0.696
	30–60	20.6 \pm 36.7	
PCT (ng/mL)	0–30	0.04 \pm 0.02	0.558
	30–60	0.07 \pm 0.06	
24 h postoperatively			
WBC ($\times 10^9$ /L)	0–30	9.2 \pm 2.5	0.989
	30–60	9.1 \pm 1.7	
CRPP (mg/L)	0–30	5.4 \pm 8.1	0.670
	30–60	16.4 \pm 30.6	
PCT (ng/mL)	0–30	0.05 \pm 0.04	0.186
	30–60	0.06 \pm 0.04	

Note: Abbreviations: SD, standard deviation; WBC, white blood cell; PCT, procalcitonin; CRP, C-reactive protein.

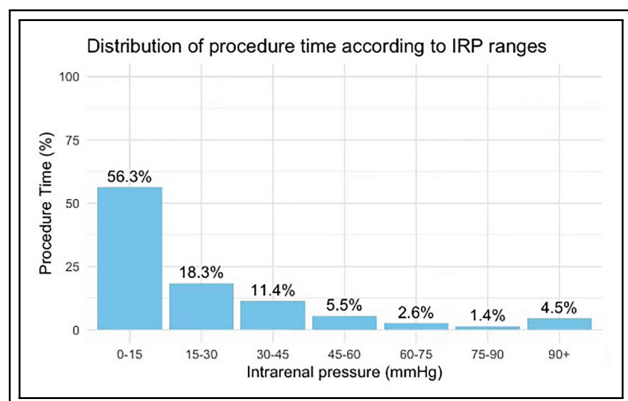


FIGURE 3. Distribution of surgical time by different intrarenal pressure (IRP) ranges

275° deflection and a 12.5° stereoscopic offset, facilitating access to lower-pole calyces with small infundibulopelvic angles. The scope's tip contains a fiber-optic pressure sensor, with data transmitted via the handle to the pressure console. The pressure threshold is preset to 30 mmHg. Besides real-time pressure values, the system displays cumulative high-pressure duration, most recent high-pressure duration, pressure curves, and the Zebra Index in real-time.

We conducted a prospective study on 35 patients (38 renal units) undergoing RIRS using the Zebra[®]

pressure-sensing ureteroscope. For cases with physiological ureteral stenosis where sheath placement was difficult, we performed visual balloon dilation to ensure successful surgery. Our results showed that UAS position significantly affected IRP. In 9 cases, due to narrow or tortuous ureters, the UAS was placed at a low position, limiting fluid outflow and resulting in higher IRP. Compared with the standard UAS group, the low-position UAS group had significantly higher high and peak IRP values and longer cumulative durations above the pressure threshold ($p < 0.05$). Previous studies¹⁶ suggest that thicker UAS or smaller sheath-to-scope ratios help control IRP and reduce postoperative infections. However, in our study, although there were IRP differences between Fr11/13 and Fr12/14 UAS groups (ratios of endoscope-sheath diameter were 0.78 and 0.75, respectively), the differences were not statistically significant. This may be due to the use of gravity irrigation or low-speed pumps and the relatively small diameter of the endoscope. Our analysis also found that BMI significantly influenced IRP. Overweight patients had higher mean IRP than those with normal BMI, possibly due to smaller collecting system volumes and narrower ureters observed on preoperative CT and intraoperative endoscopy.

We divided average IRP into four subgroups: safe (≤ 30 mmHg), moderate (30–60 mmHg), high (60–90 mmHg), and ultra-high (> 90 mmHg), and analyzed correlations with infection risk. At both 2-

and 24-h post-op, there were no significant differences in infection markers (WBC, PCT, CRP) between the safe and moderate IRP groups ($p > 0.05$). This suggests that the current 30 mmHg safety threshold may be too conservative, particularly under conditions of low irrigation flow and short operative times (mean 45.2 ± 8.3 min). Therefore, whether the safety threshold of IRP can be extended to 60mmHg under these two factors, a larger sample size and clinical practice are needed to verify. Analysis of IRP time distribution showed that IRP was maintained below 60 mmHg for 91.5% of the total operative time, and below 15 mmHg for 56.3%. No Clavien-Dindo grade \geq II complications occurred, suggesting that controlling IRP is key to preventing postoperative bleeding, trauma, and infection.

This study has limitations. Although prospective, it was single-center, lacked a control group, and had a limited sample size. Furthermore, since surgeons could see real-time IRP data, they may have altered their behavior during surgery to reduce pressure, introducing potential bias. Future multi-center prospective randomized controlled trials are planned to address these limitations and validate our findings. Despite these limitations, this is the first domestic clinical study using a disposable ureteroscope with IRP monitoring. Real-time IRP monitoring during RIRS may help identify patients at risk for pressure-related complications and guide intraoperative decision-making to enhance surgical safety. The pressure-sensing ureteroscope is poised to usher in a new era of IRP-monitored RIRS.

Conclusions

A disposable IRP measuring flexible ureteroscope can monitor real-time changes in IRP in RIRS, and the surgeon can adjust and optimize surgical strategies based on pressure data to ensure surgical safety. Low UAS and high BMI are risk factors for elevated IRP. Under the condition of ensuring a relatively low perfusion flow rate, a pressure range of 30–60 mmHg should be considered as the ideal safe threshold for IRP.

Acknowledgement

None.

Funding Statement

This research was funded by a horizontal project of Beijing Tsinghua Changgung Hospital, with grant number 12024C06004. The funding was supported by Happiness Workshop Medical Instruments Co., Ltd. (Bengbu, China, <https://www.hwmeds.com/contactus.html>).

Author Contributions

Yubao Liu conceptualized the study and drafted the manuscript. Zheng Xu provided data collection and visualization. Haifeng Song, Boxing Su, and Bixiao Wang were responsible for validation. Weiguo Hu, Bo Xiao, and Gang Zhang contributed to the interpretation of results. Jianxing Li supervised the project. All authors reviewed the results and approved the final version of the manuscript.

Availability of Data and Materials

The datasets supporting the conclusions of this article are included within the article.

Ethics Approval

This study involving human participants was reviewed and approved by the Ethics Committee of Beijing Tsinghua Changgung Hospital. The approval number is 23349-0-02.

Informed Consent

All participants provided their written informed consent to participate in this study.

Conflicts of Interest

The authors declare no conflicts of interest to report regarding the present study.

References

1. Fayad MK, Fahmy O, Abulazayem KM, Salama NM. Retrograde intrarenal surgery versus percutaneous nephrolithotomy for treatment of renal pelvic stone more than 2 centimeters: a prospective randomized controlled

- trial. *Urolithiasis* 2022;50(1):113–117. doi:10.1007/s00240-021-01289-9.
2. Proietti S, Dragos L, Molina W, Doizi S, Giusti G, Traxer O. Comparison of new single-use digital flexible ureteroscope versus nondisposable fiber optic and digital ureteroscope in a cadaveric model. *J Endourol* 2016;30(6):655–659. doi:10.1089/end.2016.0051.
 3. Doizi S, Kamphuis G, Giusti G et al. First clinical evaluation of a new single-use flexible ureteroscope (LithoVue™): a European prospective multicentric feasibility study. *World J Urol* 2017;35(5):809–818. doi:10.1007/s00345-016-1936-x.
 4. Qi S, Yang E, Bao J et al. Single-use versus reusable digital flexible ureteroscopes for the treatment of renal calculi: a prospective multicenter randomized controlled trial. *J Endourol* 2020;34(1):18–24. doi:10.1089/end.2019.0473.
 5. Urology EAo. EAU guidelines. In: *EAU Annual Congress*. Madrid, Spain: European Association of Urology; 2025.
 6. Zeng G, Zhao Z, Mazzon G et al. European association of urology section of urolithiasis and international alliance of urolithiasis joint consensus on retrograde intrarenal surgery for the management of renal stones. *Eur Urol Focus* 2022;8(5):1461–1468. doi:10.1016/j.euf.2021.10.011.
 7. Barone B, Crocetto F, Vitale R et al. Retrograde intrarenal surgery versus percutaneous nephrolithotomy for renal stones >2 cm. A systematic review and meta-analysis. *Minerva Urol Nefrol* 2020;72(4):441–450. doi:10.23736/S0393-2249.20.03721-2.
 8. Osther PJS. Risks of flexible ureterorenoscopy: pathophysiology and prevention. *Urolithiasis* 2018;46(1):59–67. doi:10.1007/s00240-017-1018-6.
 9. Doizi S. Intrarenal pressure: what is acceptable for flexible ureteroscopy and percutaneous nephrolithotomy? *Eur Urol Focus* 2021;7(1):31–33. doi:10.1016/j.euf.2021.01.010.
 10. Kottooran C, Twum-Ampofo J, Lee J et al. Evaluation of fluid absorption during flexible ureteroscopy in an *in vivo* porcine model. *BJU Int* 2023;131(2):213–218. doi:10.1111/bju.15858.
 11. Sixing Y, Fu Z, Qin K et al. Monitoring of renal pelvic pressure and its significance during flexible ureteroscopic lithotripsy. *Chin J Urol* 2014;35(8):575–578. doi:10.3760/cma.j.issn.1000-6702.2014.08.004.
 12. Jung H, Osther PJS. Intraluminal pressure profiles during flexible ureterorenoscopy. *Springerplus* 2015;4(1):373. doi:10.1186/s40064-015-1114-4.
 13. Huang X, He X, Zhai Q, Song L, Du C, Deng X. Ureteroscopic lithotripsy with pressure-measuring ureteral access sheath for large ureteral stones. *Minim Invasive Ther Allied Technol* 2024;33(3):157–162. doi:10.1080/13645706.2024.2306813.
 14. Doizi S, Letendre J, Cloutier J, Ploumidis A, Traxer O. Continuous monitoring of intrapelvic pressure during flexible ureteroscopy using a sensor wire: a pilot study. *World J Urol* 2021;39(2):555–561. doi:10.1007/s00345-020-03216-w.
 15. Bhojani N, Koo KC, Bensaadi K, Halawani A, Wong VK, Chew BH. Retrospective first-in-human use of the LithoVue™ Elite ureteroscope to measure intrarenal pressure. *BJU Int* 2023;132(6):678–685. doi:10.1111/bju.16173.
 16. Fang L, Xie G, Zheng Z et al. The effect of ratio of endoscope-sheath diameter on intrapelvic pressure during flexible ureteroscopic lasertripsy. *J Endourol* 2019;33(2):132–139. doi:10.1089/end.2018.0774.